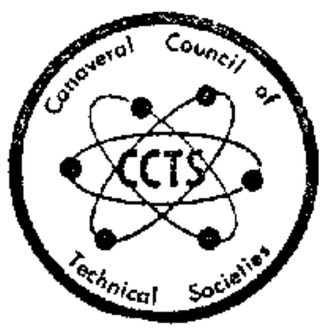
SIXTH SPACE CONGRESS

SPACE, TECHNOLOGY, AND SOCIETY

COCOA BEACH, FLORIDA

proceedings

MARCH 17, 18, 19, 1969



A REAL-TIME FISHERIES SATELLITE SYSTEM [1/]

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Summary

The capability of surveying the world ocean each day to follow the distribution of surface temperatures, currents, water-mass boundaries, and areas of vertical water motion, provides the synoptic oceanography needed for real-time fishery location. By continuous, environmental monitoring, deviations from the normal can be known, and forecasting the fishable population of a given fishery can be a reality.

Introduction

By detailed evaluations of space photography from manned and unmanned vehicles, we have learned which ocean-surface features can be sensed from orbiting spacecraft. Most features such as ocean currents, eddies, and diverging systems, are produced by water movements in the upper 500 meters of the sea. Some are produced by turbulence in ocean currents that results from topographic irregularities of the sea floor. Included in this category are island wakes and wave refraction. In each case, the condition of the sea surface has some significance to the distribution of fisheries.

Island Wakes

Socotra, an island of the Aden Protectorate of South Arabia, lies in the Arabian Sea some 260 kilometers east of Somaliland. Southwest of Socotra, on the extension of the insular shelf, are the two small islands, The Brothers. During the flight of Apollo 7, in October 1968, the astronauts took a striking photograph at a time near local noon when the sunlight was reflecting from the waters southwest of Socotra (Figure 1). The red color of the islands, and the reddish hue of the sun's reflection, are the result of the SO-121 film and the filter-lens combination on the Hasselblad camera.

The transition period between the southwest monsoons of the summer and the prevailing northwesterlies of the winter months is from September through the early part of November. Winds are light and variable, and are gently blowing land and sea breezes. Such was the case when this photograph was taken.

The currents and features of the ocean surface visible in the sun's reflection were the result of currents caused by the ebbing tide. The water was flowing from the north side of the islands and a counter-clockwise-rotating von Karman vortex was formed as it moved by the western tip of Socotra. Smaller vortices were in the waters behind The Brothers.

Island wakes in distinct vortices had not been photographed previously. The existence of such features had been known, however, as had the concentration of certain fisheries in such waters. The size and configuration of island wakes, and whether or not they actually formed into von Karman vortices were not certain before the acquisition of this photograph.

Ocean-Surface Features With Distinct Gradients

Oceanographic features visible from space have been interpreted only from color photographs, and are, therefore, responding in the visual spectrum. Many features, however, have characteristics that can be measured in other portions of the electromagnetic spectrum. For example, island wakes, and converging and diverging systems have temperature gradients of several degrees across their boundaries. Furthermore, wind waves on the sea surface form "texture patterns" that are caused by the horizontal water motion relative to the immediate wind field. Consequently, surface roughness (texture) of the sea outlines oceanographic features, in some cases, more precisely than temperature gradients.

A portion of east Africa and the Arabian Peninsula was photographed from an altitude of about 700 kilometers on September 14, 1966 (Figure 2). The sun reflected from the land area and the edge of the reflection extended over the western end of the Gulf of Aden. The variation of the blue hue of the water was caused by differences in roughness of the water surface. The light blue was rough (more waves) water and the dark blue the smooth (less waves) water.

The large eddy, noted by the dark water, was composed of waters that flowed from the Red Sea into the Gulf of Aden, and eventually east to the Indian Ocean. The portion of the flow visible in this photograph measures about

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1/Contribution No. 287, Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas.

390 kilometers long and 170 kilometers in diameter. This size constitutes a large ocean-current system. The significant populations of tuna, sardines, and anchovy in the western Gulf of Aden are associated with these flowing waters.

Ocean Features and Their Relationship to Fisheries

The capability of surveying the world ocean each day to follow the distribution of surface temperatures, currents, water-mass boundaries, and areas of vertical water motion, provides the synoptic oceanography needed for real-time fishery location. Fisheries related to boundaries in the ocean, whether defined by temperature, currents, or water quality, can be pin-pointed and followed. Such a capability would reduce the "hunting time" of a fleet, or vessel, by as much as 70 percent, depending on the characteristics of the particular fishery.

The greatest problem in forecasting the fishable population of a given fishery is to develop a method of continuous acquisition of data from which deviations from the normal environment can be known. The range of deviations must be known with considerable precision during the early life (from spawning to the juvenile stage) of many commercial species. This period may vary from 2 weeks to 6 months, depending on the species. Any major deviation from the normal environment, even though of short duration, can be fatal to the individuals. The capability of acquiring data continuously does not now exist for the open ocean. It could be developed, however, from the constant daily surveillance by space-borne sensors.

It is clear, therefore, that a suitable acquisition-assimilation system can provide data from which real-time fishery location, and long-range, accurate, fishing forecasts can be realized. Many gaps must be filled in the space model and the fishery-oceanography model before a fishery satellite system is a reality. None are, however, beyond the capabilities of the prevailing technology -- in either field.

Figure 1 Islands of Socotra and The Brothers, off the coast of Somali, Africa, in the Indian Ocean, taken during the flight of Apollo 7, October 15, 1968, by astronauts Walter M. Schirra, Donn F. Eisele, and R. Walter Cunningham, from an altitude of about 170 kilometers. The camera used was a NASA-modified Hasselblad 500 C, with a Zeiss Planar, 80-mm focal length lens. National Aeronautics and Space Administration/Manned Spacecraft Center Color Photo No. AS7-7-1779.

LOW QUALITY XEROX